Instantaneous acceleration vector in wing-propelled alcid during flight and swimming

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Alcids are capable of aerial flight and underwater swimming with its wings. Such bird species must attain both locomotion in the air and water that have vastly different density. To achieve steady flight, birds must counteract gravity by producing lift, and support its weight in air. In contrast, to achieve horizontal and descent swimming, birds must counteract buoyancy by producing downforce, and prevent floating to the water surface. During flight and swimming, flapping birds will accelerate and decelerate throughout a wingbeat cycle unlike aircraft. It is assumed average acceleration vector is zero over the complete cycle in steady phase. Therefore, we examine the acceleration vector during the upstroke and downstroke phases of the wingbeat cycle. To obtain instantaneous acceleration vector, we attached inertial-logger (gyroscope and accelerometer) and depth-logger on free ranging rhinoceros auklets *cerorhinca monocerata* breeding on Teuri Island, Japan. Instantaneous acceleration vectors were calculated from logged data using orientation filter. We explore how alcids change acceleration vector against gravity and buoyancy within wingbeat cycles during flight and swimming. We found that downstroke produced upward acceleration vector in both flight and swimming. However, we found difference in direction of acceleration vector during upstroke. During flight, upstroke produced upward acceleration vector (i.e. lift) to support its weight. In contrast, during swimming, upstroke produced downward acceleration vector (i.e. downforce) to prevent floating to water surface. Rhinoceros auklets changed the acceleration vector (i.e. force direction) during upstroke phase between flight and swimming.